Implementation Monitoring of FORESTRY BEST MANAGEMENT PRACTICES on Harvested Sites in South Carolina

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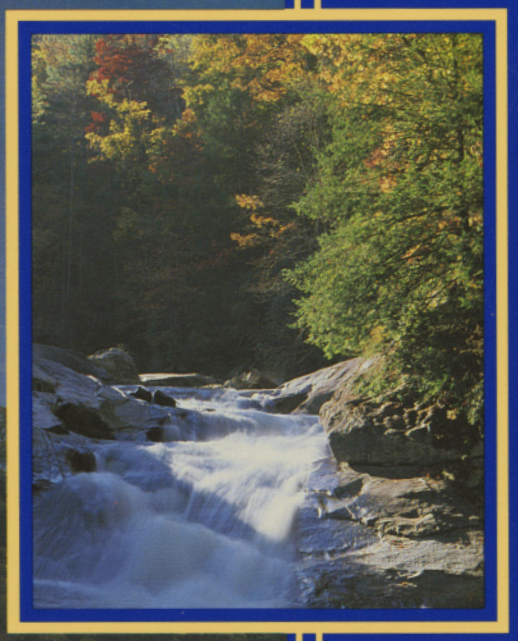

with emphasis on BMP compliance in the Blue Ridge Mountains

Implementation Monitoring of FORESTRY BEST MANAGEMENT PRACTICES on Harvested Sites in South Carolina

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Best Management Practices Monitoring Report BMP-2

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INTRODUCTION

In South Carolina, silvicultural guidelines were first published in 1976 by the South Carolina Forestry Association. Best Management Practices for South Carolina's Forest Wetlands was published by the South Carolina Forestry Commission (SCFC) in 1989. Silvicultural guidelines were updated in 1994 when the SCFC published South Carolina's Best Management Practices for Forestry to replace the two earlier manuals.

Compliance with Best Management Practices (BMPs) has been surveyed twice in South Carolina. Overall BMP compliance was 84.5% in the first survey in 1990* and 84.7% in the second survey in 1991.** The current study was designed to update the statewide level of BMP compliance from previous surveys with emphasis placed on BMP compliance in the Blue Ridge Mountains of South Carolina.

STUDY METHODS

Site Location

Two hundred harvested sites were located in South Carolina for evaluation of BMP compliance. The number of sites selected was based on the sample size needed for statistical analysis. BMP compliance checks were made on harvested sites that were no older than one year old. Most of the sites were logged between mid-1992 and mid-1993, and they were inspected during the spring and summer of 1993. Also, harvested sites had to be a minimum of 10 acres. No site was sampled that had been site prepared. Harvested sites were not required to be associated with streams or wetland areas as was the case in the first round of monitoring in 1990.

Selected sites were distributed in proportion to the volume of timber harvested in all counties except those in the Blue Ridge Mountain region.

*Hook, D.D., W. McKee, T. Williams, B. Baker, L. Lundquist, R. Martin, and J. Mills. 1991. A Survey of Voluntary Compliance of Forestry Best Management Practices. South Carolina Forestry Commission. Columbia, South Carolina. 23 p.

**Adams, T. and D. Hook. 1993. Implementation and Effectiveness Monitoring of Forestry Best Management Practices on Harvested Sites in South Carolina. South Carolina Forestry Commission. Columbia, South Carolina. 32 p.

The average volume of timber harvested in individual counties was based on unpublished annual timber harvest data collected by the U.S. Forest Service. Outside the Blue Ridge Mountain region, the number of sites sampled within any particular county was in proportion to the percent of that county's harvest in relation to the entire state. In the Blue Ridge Mountain region, all harvested sites that met sample site criteria were evaluated. Statewide, the number of sites located within individual counties ranged from one to fifteen sites. Sites were identified by SCFC foresters from fixed-wing aircraft.

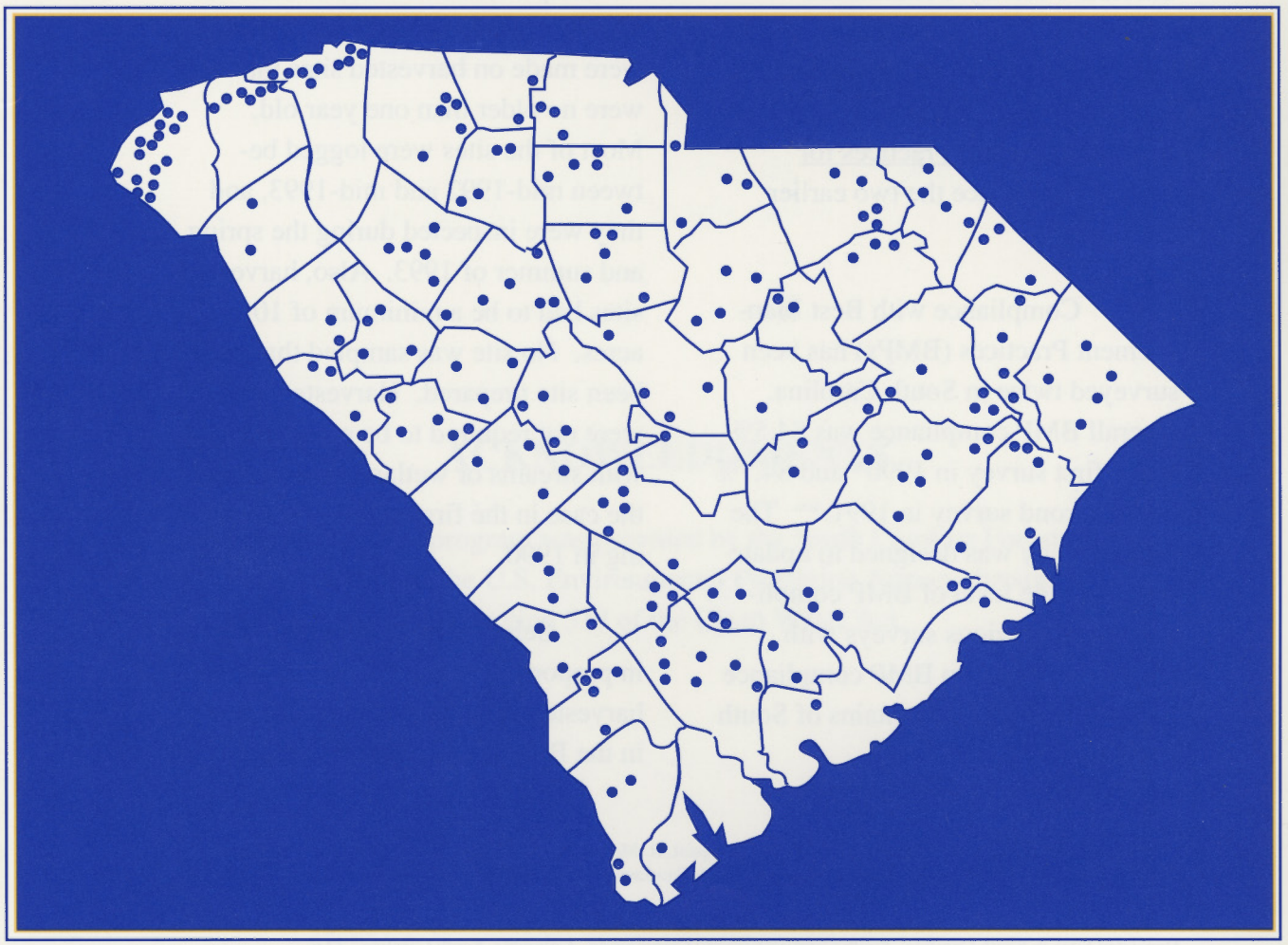


Figure 1. Two hundred harvested sites were evaluated for BMP compliance.

Landowner Questionnaire

SCFC foresters contacted all landowners whose sites were selected for BMP compliance checks. Four categories of landowners were recognized for the purpose of this study: (1) non-industrial private landowners who own less than 1,000 acres of forestland, (2) non-industrial private landowners who own more than 1,000 acres of forestland, (3) public lands (both state and federal), and (4) industrial lands. Prior to site inspection, landowners were questioned concerning their familiarity with BMPs, their use of a professional forester, their use of a written sales contract, and whether compliance with BMPs had been required of the harvesting contractor.

BMP Compliance Inspection

Site inspections were made during the spring, summer, and fall of 1993. The evaluations were made by a two-person team of SCFC foresters consisting of the forest hydrologist and the project forester. The inspection covered compliance with BMPs in each of five categories: (1) road systems, (2) road stream crossings, (3) streamside management zones (SMZs), (4) log decks, and (5) harvesting operations. Each major category was evaluated on a pass/fail basis depending on the responses to a series of yes/no questions within each category.

Each harvesting operation was rated for overall BMP compliance after all individual BMPs were fully evaluated. Sites were categorized as either excellent, adequate, or inadequate depending on the level of BMP compliance. The overall compliance rating, though subjective, was based on compliance with specific BMPs as noted throughout the evaluation. When sites were rated as inadequate, the major problems on that site were identified. Sites were rated as inadequate when non-compliance with recommended water quality related BMPs resulted in an evident off-site water quality impact. This is in contrast to the two previous BMP compliance surveys, in which sites

were rated as inadequate for non-compliance with either water quality related BMPs or site productivity related BMPs. This change in BMP compliance evaluation was necessary in order to accurately describe the impact of harvesting operations on the water quality of associated streams.

Statistical Analysis

Compliance values were computed for each of the five main BMP categories as well as for overall BMP implementation. BMP compliance estimates were weighted by physiographic regions to remove the bias caused by intensive sampling in the Blue Ridge Mountains. A 95% confidence interval was calculated for each compliance value. Problems which contributed to non-compliance were identified for each of the major BMP categories and overall BMP implementation.

Sixteen variables, including site characteristics and management decisions, were identified which could have possibly affected the level of BMP compliance. All of these variables were evaluated through landowner interviews or by on-site inspection of the harvesting operations. Statistical analysis was performed on each of these variables to determine the significance of their relationship with BMP compliance.

MONITORING RESULTS

BMP compliance checks were completed on 200 harvested sites between June 1, 1993 and September 30, 1993. Thirty of the 200 sites were located in the Blue Ridge Mountain region. The difference in sampling intensity within the Blue Ridge Mountain region and the rest of the state required a weighting of BMP compliance results to eliminate bias. Compliance with each of the five major BMP categories and overall BMP compliance is summarized as follows.

96.0%
acceptable

Road Systems

Compliance with road construction and maintenance BMPs was high when considering road stream crossings separately. Statewide, 145 out of the 200 sites that were evaluated involved roadwork. Of these 145 sites, 136 sites had acceptable compliance with road BMPs, and only 9 sites were rated as inadequate. Five of the 9 sites that were rated inadequate were in the Blue Ridge Mountains. Statewide compliance with road BMPs was 96.0% when the data was weighted by physiographic region to remove the bias caused by intensive sampling in the Blue Ridge Mountains. Compliance with road BMPs in this survey averaged higher than the 92% level of compliance that was reported in the last survey (Adams and Hook, 1993).

Inadequate ratings were due to the lack of adequate water diversion structures and emptying of road ditches directly into streams. All nine sites with inadequate road systems lacked adequate water diversion structures, and eight of these nine sites had road ditches which emptied directly into streams. Road layout, filter strip width, and road slope were not significant problems on a statewide basis.

Picture 1. The use of rock surfacing, broad-based dips, and seeding the road shoulders with grass created stable conditions on this road.

Picture 2. The lack of water diversion structures on this road resulted in erosion and deposition of sediment downhill.

Picture 3. Proper construction of culverted stream crossings include using culverts that are long enough to extend beyond the toe of the fill, sizing culverts for expected storm flows, and stabilization of fill material.

Picture 4. Lack of road water diversion structures uphill of this road stream crossing allowed road runoff to erode fill material.

Road Stream Crossings

79.5% acceptable

Compliance with road stream crossing BMPs improved significantly since the last survey. Of the 200 sites that were inspected in this study, 32 sites involved road stream crossings. Of these 32 sites, 22 were designed, constructed, and maintained according to BMPs. Ten sites were rated as inadequate for road stream crossing BMPs. Six of these 10 sites were located in the Blue Ridge Mountains and 4 sites were located in the Southern Piedmont. No site received an inadequate rating for road stream crossings in the sandhill or coastal regions of the state. Statewide compliance with road stream crossing BMPs was 79.5% when the data was weighted by physiographic region to remove the bias caused by intensive sampling in the Blue Ridge Mountains. Compliance with road stream crossing BMPs was 41.7% in the last survey (Adams and Hook, 1993).

The most common type of road stream crossing was the installation of culverts with soil fill. Sites with adequate ratings tended to utilize all stream crossing methods where appropriate. Sites with inadequate ratings tended to rely on two types of crossings, culvert with soil fill crossings and debris fill crossings with a soil cap. All crossings that were inspected were generally unavoidable. Where culverted crossings received inadequate ratings, the culverts were generally undersized or improperly installed, and fill material was not stabilized. The impact of poorly designed crossings was generally visible downstream.

79.9%
acceptable

Streamside Management Zones

Compliance with streamside management zone (SMZ) BMPs, when weighted by physiographic region, averaged 72.4% in the last survey as compared to 79.9% in the this survey. Of the 200 sites that were inspected, 92 harvested sites had perennial streams on which SMZs were recommended. Statewide, 71 of these 92 sites had acceptable SMZs with 21 sites being rated inadequate for SMZ compliance. Of the 21 sites with inadequate SMZ compliance, 8 sites were located in the Blue Ridge Mountains, 8 sites were in the Southern Piedmont, 1 site was in the Carolina Sandhills, and 4 sites were in the Atlantic Coast Flatwoods. SMZs were not evaluated for intermittent or ephemeral streams in this study.

A slightly higher percentage of sites with inadequate SMZs occurred where slopes exceeded 20%. Inadequate SMZs were generally due to the total absence of SMZs rather than SMZs being narrower than recommended. In evaluating SMZs, the team did not find an SMZ inadequate if it was only slightly narrower than the recommended width. Inadequate ratings were attributed to the indiscriminant use of vehicles in the SMZ, the introduction of woody debris in the stream, and the movement of sediment across narrow SMZs .

Picture 5. SMZs are useful in breaking up the visual impact of the clearcut, serving as wildlife corridors, and filtering out sediment from runoff.

Picture 6. Removal of SMZs allowed runoff from eroding skid trails to deposit fresh sediment in the stream.

99.2%
acceptable

Log Decks

Compliance with log deck BMPs was the highest of the major BMP categories. Of the 200 sites that were inspected, 197 sites received adequate ratings for log deck BMP compliance. The three inadequate log decks were due to their location within a primary streamside management zone, their lack of soil stabilization following logging, or the excessive discharge of fuel/oil and garbage at the deck. Two of the 3 sites with inadequate log deck rating were located in the Blue Ridge Mountains, and 1 site was located in the Southern Piedmont. Statewide compliance with log deck BMPs was 99.2% when weighted by physiographic region.

Picture 7. This log deck was correctly placed on high ground away from drainages. Upon completion of the harvest, the deck was seeded with grass.

Picture 8. How many log deck BMP violations can you find in this photo? The deck is placed on low ground, concentrating roads, skid trails, and the resulting runoff into the nearby stream. Also, the deck is actually within the SMZ as is the oil and hydraulic fluid which are visible in the foreground.

90.6%
acceptable

Harvesting Operations

The harvesting operation was evaluated on all 200 sites with 178 sites receiving adequate ratings. Harvesting operation BMP compliance was 90.6% when weighted by physiographic region. Of the 22 sites which received inadequate harvesting ratings, 7 sites were in the Blue Ridge Mountains, 10 sites were in the Southern Piedmont, and 5 sites were in the Atlantic Coast Flatwoods. Practices evaluated included: (1) layout of the skid trails, (2) drainage crossings, (3) soil moisture conditions during logging, (4) degree of rutting, and (5) percent of area impacted by skidding equipment. Ruts were considered to be deep if they were over 10 inches deep. The evaluation of harvesting operations in this survey differs from past surveys in that no site received inadequate ratings for excessive rutting if the risk of impacts to water quality were nonexistent. Deep rutting was excessive on 12 of the 200 sites that were inspected. However, only 3 of the 12 sites with excessive deep rutting received an unacceptable BMP rating due to likely water quality impacts.

Picture 9. The skid trails on this property were designed to follow the ridge lines and eliminate any unnecessary stream crossings.

Picture 10. The primary skid trail on this low-lying property followed the sandy stream channel. Although a common practice in the past, current BMPs recommend skidding within the stream channel only in isolated, well-designed crossings.

89.5%
acceptable

Overall BMP Compliance

Overall BMP compliance in South Carolina, when weighted by physiographic region, was 89.5% as compared to 84.7% compliance in the last survey. Of the 200 sites inspected, 70 sites rated excellent, 103 sites rated adequate, and 27 sites rated inadequate. Sites with inadequate compliance ratings were primarily located in the Piedmont and Blue Ridge Mountain regions of the state. Only 5 inadequate sites were located in the coastal regions. The major problems that were identified on inadequate sites are listed below.

Sites with excellent overall BMP compliance ratings scored well on all five individual BMP categories. Adequate sites scored well on all BMP categories except stream crossing BMPs. In contrast, inadequate sites scored low on all categories except for log deck BMPs. Road stream crossing and streamside management zone BMPs appeared to be the most difficult BMP categories with which to comply.

The majority of sites with both adequate and inadequate harvesting compliance ratings had between 10% and 20% of the area disturbed by skidding equipment. There was a slight trend for sites with inadequate ratings to have greater than 20% of the area impacted. The major problems which resulted in inadequate harvesting operation BMP compliance were due to skid trail design and skid trail stream crossings. The main skid trails were designed appropriately on only 31.8% of the sites which were rated inadequate for harvesting BMP compliance. On sites with inadequate harvesting BMP compliance ratings, skidding equipment crossed 81% of all perennial and 100% of all ephemeral streams. These crossings primarily involved the use of either debris or soil fill. Fords were the most common type of skid trail stream crossing on sites with adequate harvesting BMP ratings. Erosion from the skid trails or skid trail stream crossing fill material contributed to inadequate ratings.

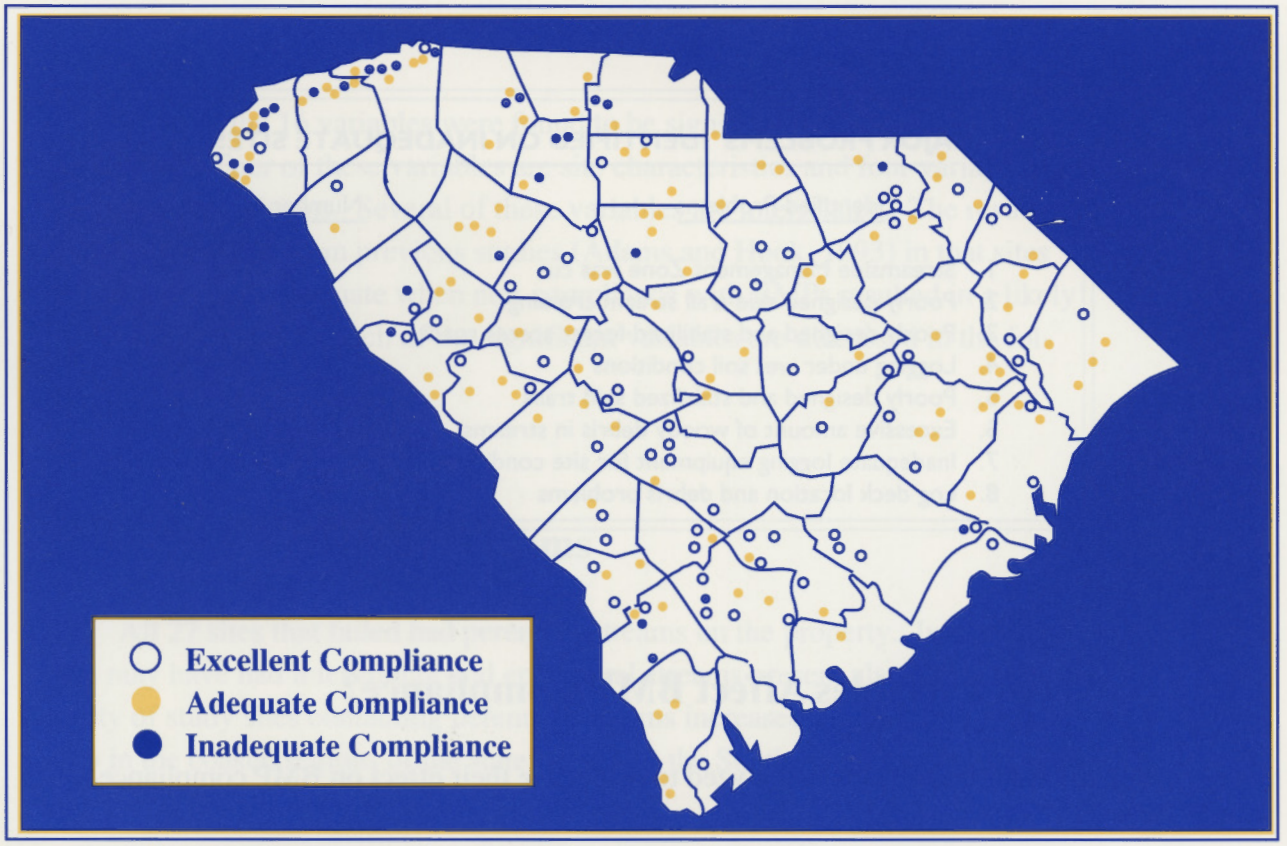


Figure 2. Of the 200 sites inspected, 70 sites rated excellent, 103 sites rated adequate, and 27 sites rated inadequate.

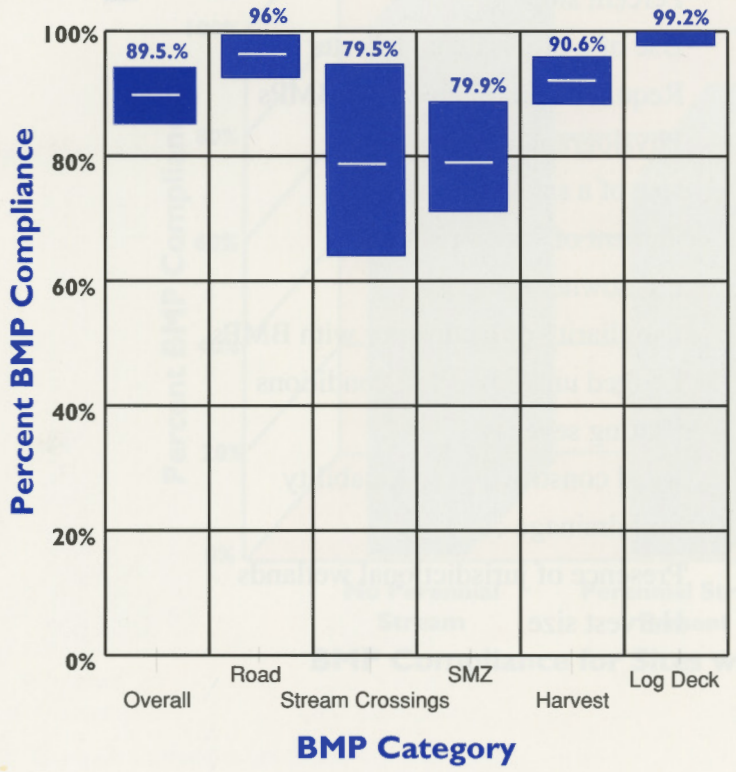


Figure 3. Compliance is shown for the 5 major BMP categories and overall BMP compliance along with 95% confidence intervals.

MAJOR PROBLEMS IDENTIFIED ON INADEQUATE SITES

Identified Problems	Number of Comments
1. Streamside Management Zone was cut	20
2. Poorly designed skid trail stream crossing	18
3. Poorly designed and stabilized forest access roads	15
4. Logging under wet soil conditions	13
5. Poorly designed and stabilized skid trails	12
6. Excessive amount of woody debris in streams	6
7. Inadequate logging equipment for site conditions	4
8. Log deck location and debris problems	3

What Variables Affect BMP Compliance?

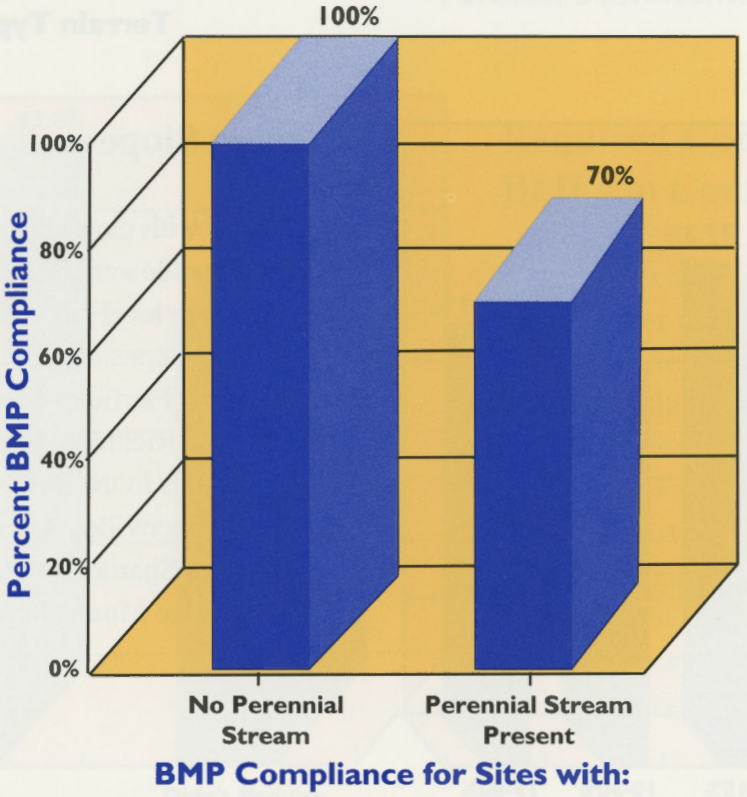
Sixteen variables were analyzed to determine their effect on BMP compliance.

- Presence of perennial streams
- Terrain type
- Percent slope
- Use of a professional forester
- Required compliance with BMPs
- Physiographic region
- Use of a sales contract
- Percent of site impacted
- Landowner category
- Familiarity of landowner with BMPs
- Logged under wet soil conditions
- Rutting severity
- Road construction applicability
- Soil drainage class
- Presence of jurisdictional wetlands
- Harvest size

Eight of the 16 variables were found to be significantly related to BMP compliance. Four of these variables are site characteristics and four variables are management decisions. Several of these variables are interrelated. The results of this analysis differ from previous studies (Adams and Hook, 1993) in that sites were only rated inadequate when non-compliance with BMPs resulted in a likely water quality impact. Each of the significant variables are discussed in the following pages.

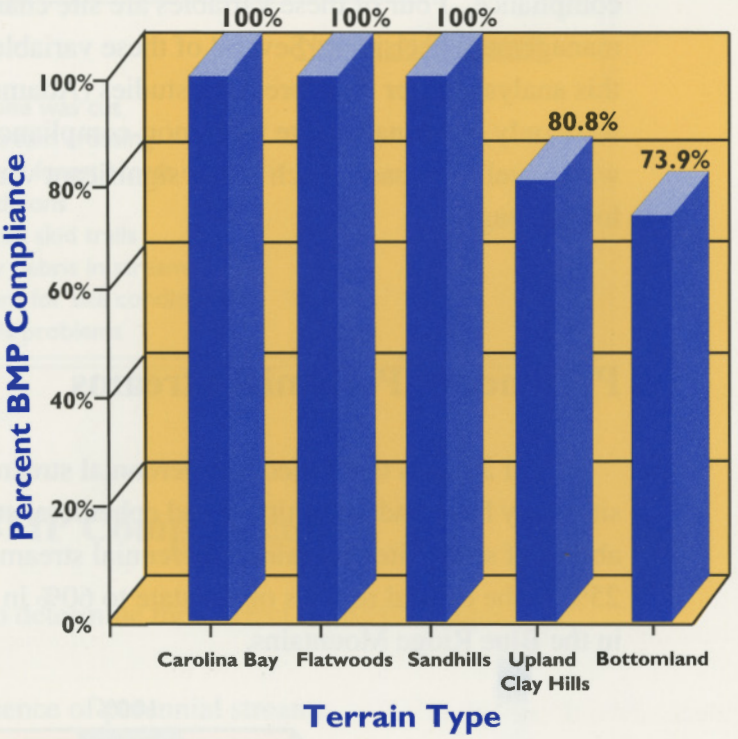
Presence of Perennial Streams

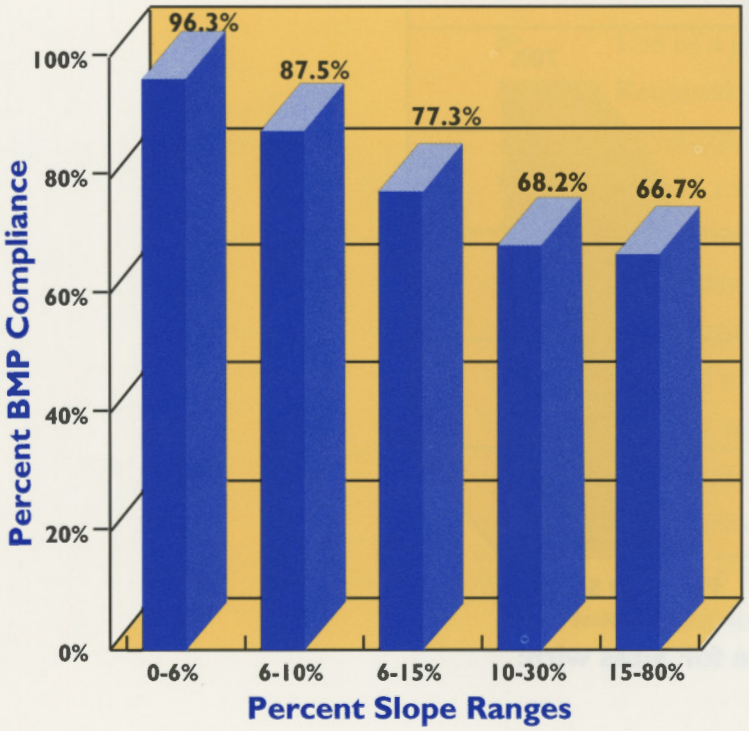
All 27 sites that failed had perennial streams on the property. Inadequate sites may have had intermittent and ephemeral streams present also. The probability of study sites containing perennial streams increased dramatically from 25% in the coastal regions of the state to 60% in the Southern Piedmont and 90% in the Blue Ridge Mountains.



Terrain Type

BMP compliance was significantly higher on Carolina Bay, pine flatwood, and sandhill sites that are characteristic of the Southern Coastal Plain and Atlantic Coast Flatwoods. BMP compliance dropped for hilly Piedmont terrain and for bottomland sites which occurred statewide.



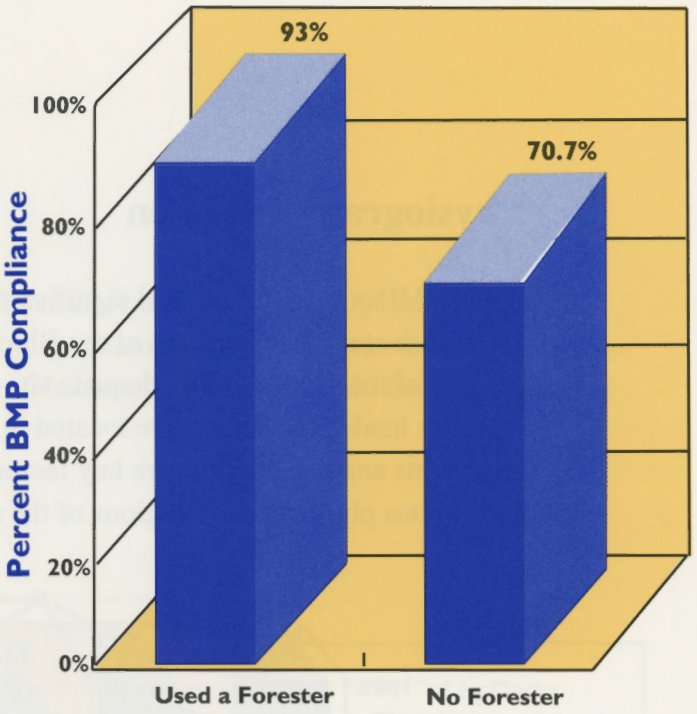


Percent Slope

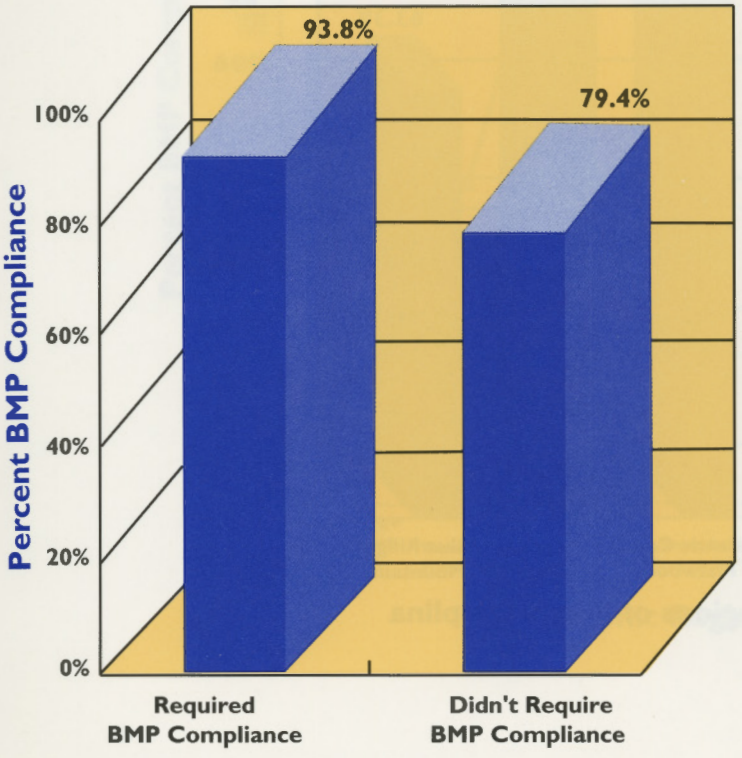
Sites with the steepest slopes generally had lower BMP compliance than the more level sites. Sites with the steepest slopes occurred in Anderson, Chester, Fairfield, Lancaster, McCormick, Richland, Union, and York Counties in the Southern Piedmont and Greenville, Oconee, Pickens, and Spartanburg Counties in the Blue Ridge Mountain regions of the state

Use of a Professional Forester

BMP compliance was significantly higher on sites where a professional forester was involved in the timber sale. A professional forester was considered to have a minimum of a 4-year college education in forestry. Foresters were involved in all public and industrial timber sales that were inspected, but foresters were only involved in 71% of large, non-industrial private sales and 60% of small, non-industrial private sales.



Forester's Involvement in Timber Sale



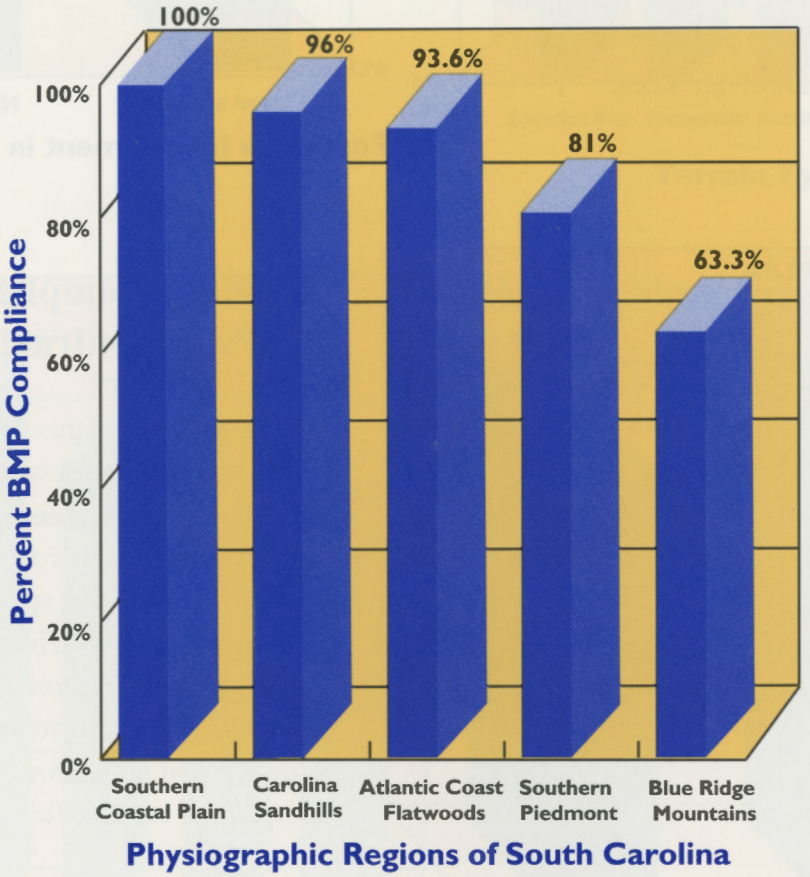
BMP Requirements in Sale Contracts

Required Compliance with BMPs in Contract

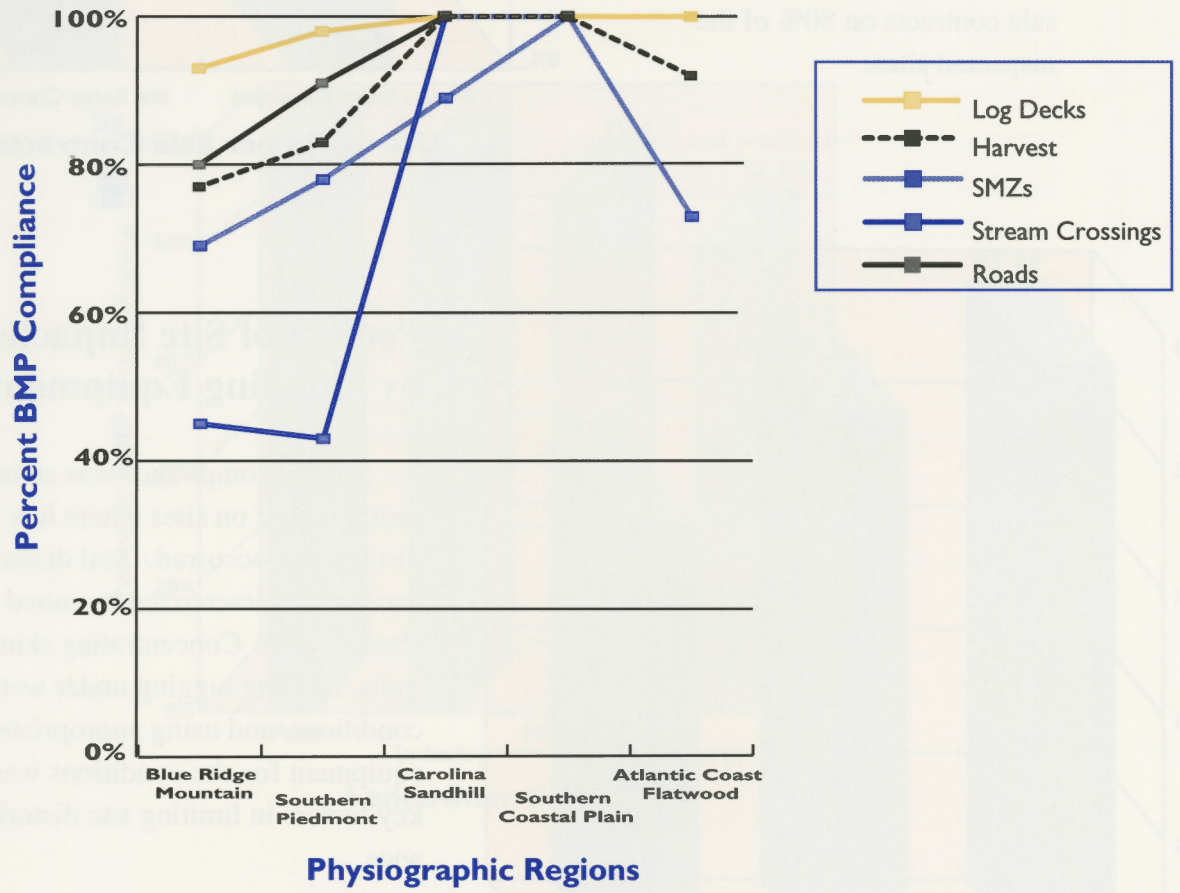
BMP compliance was significantly higher on sites where the landowners required compliance with BMPs in timber sale contracts. Contracts addressed such specifics as streamside management zones, stream crossings, road construction, and wet weather logging restrictions. Statewide, 49% of all landowners required compliance with applicable BMPs on their property.

Physiographic Region

BMP compliance varied significantly across the state. Of the 27 inadequate sites, 11 were located in each of the Blue Ridge Mountain and Southern Piedmont regions of the state. One inadequate site was located in the Carolina Sandhills, and four inadequate sites were located in the Atlantic Coast Flatwoods. Proximity to streams and land slope were key factors in affecting BMP compliance among the various physiographic regions of the state.

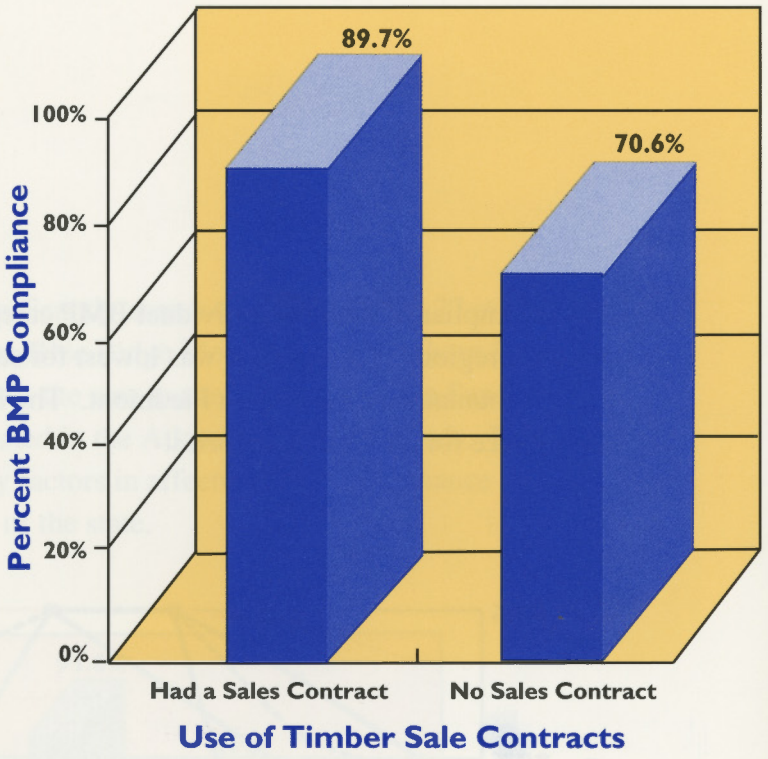


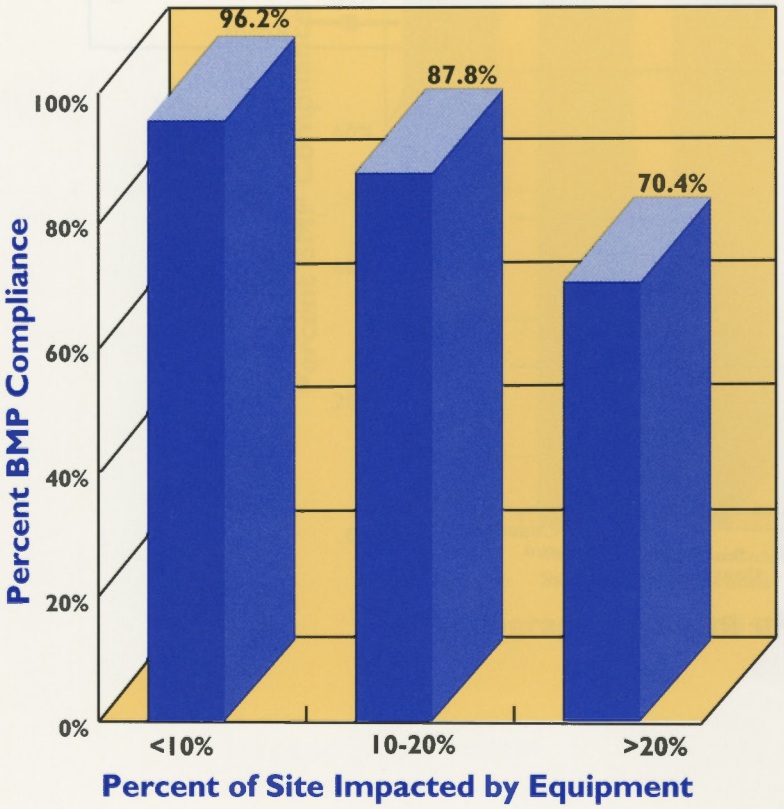
Compliance with the individual BMP categories varied among physiographic regions. Compliance was lowest for stream crossing BMPs in the Blue Ridge Mountains and Southern Piedmont. The Southern Coastal Plain had perfect compliance for all BMP categories.



Landowner's Use of Sales Contracts

BMP compliance varied significantly depending on whether a landowner used a timber sale contract. All public timber sales had timber sale contracts. Industrial landowners used timber sale contracts on 90% of the inspected sites. Private landowners used timber sale contracts on 80% of the inspected sites.



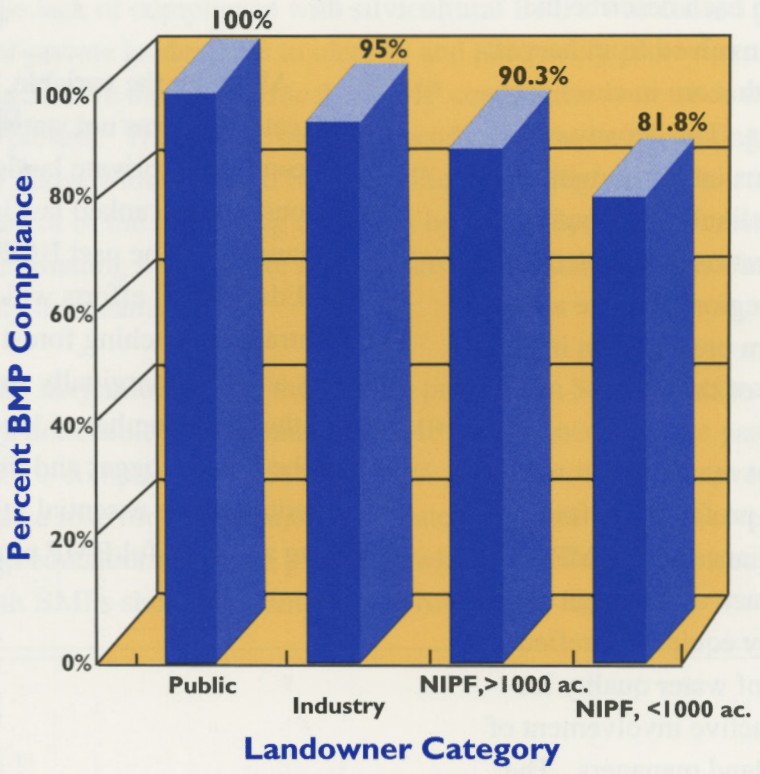


Percent of Site Impacted by Skidding Equipment

BMP compliance was significantly higher on sites where less soil disturbance occurred. Soil disturbance was characterized by rutted or churned soil. Concentrating skid trails, limiting logging under wet soil conditions, and using appropriate equipment for site conditions were all key factors in limiting site disturbance.

Landowner Category

Although not statistically significant, BMP compliance did vary among the four landowner categories. BMP compliance for public, industrial, and large, non-industrial private landowners all exceeded 90% compliance. Small, non-industrial landowners were the only ownership category whose BMP compliance, 81.8%, fell below the state average. In the Blue Ridge Mountain region, all inadequate sites were located on small, non-industrial landowners' property, whose overall BMP compliance was 56%.



Each of the variables that have been discussed in detail significantly affected BMP compliance in this study. Other variables that were studied, such as soil drainage class and soil moisture conditions, affected BMP compliance to a lesser degree. The four site characteristic variables, presence of perennial streams, terrain type, percent slope, and physiographic region each describe the increased risk involved from harvesting operations that are in close proximity to streams. The density of drainage systems increases with slope making it more likely for a typical harvesting operation in the piedmont and mountain regions to have a perennial stream present than in the coastal regions of the state.

The four management variables, use of a professional forester, required compliance with BMPs, use of a sales contract, and percent of the site impacted by equipment reflect the decreased risk of water quality impairment with active involvement of landowners or land managers. The use of a timber sales contract with specific requirements of complying with BMPs is one of the best tools available to the landowner. Professional foresters provide landowners with valuable experience in writing sale contracts and administering timber sales. Routine on-site supervision of the harvesting operation is essential in preventing both on-site and off-site impacts.

Although the variable, landowner category, was not statistically significant, small private landowners have consistently ranked last in BMP compliance over the past BMP surveys. Educational efforts which concentrate on reaching forest landowners are only marginally successful due to the large number of landowners in the state. Logger and timber buyer education is essential in implementing a successful BMP program.

SUMMARY

During the period of time reflected by this survey, compliance with silvicultural BMPs was 89.5% on harvesting operations in South Carolina. Of the five major BMP categories, compliance was highest for log deck and road BMPs, 99.2% and 96.0%, respectively. Compliance with harvesting BMPs was 90.6% with the major problems consisting of inadequate skid trail design and skid trail stream crossings. Compliance was lowest for road stream crossings and SMZs, 79.5% and 79.9%, respectively.

The lack of compliance with silvicultural BMPs was caused primarily by a failure of private landowners to identify and adequately protect sensitive sites. Sites which were the most critical to BMP compliance were sites with perennial streams present. These were most frequently present on harvesting operations in the Blue Ridge Mountain and Southern Piedmont regions of the state. Active management of the harvesting operation by the landowner or forester was essential in eliminating both on-site and off-site impacts on sites that were in close proximity to streams.

The silvicultural BMP monitoring program in South Carolina has documented a noticeable improvement in BMP compliance over the past three surveys, from 84.5% compliance in 1990 to 89.5% compliance in this survey. In fact, compliance rose for every major BMP category since the last survey. With increased educational efforts, primarily with loggers and timber buyers, compliance with BMPs should continue to improve in the future.

RECOMMENDATIONS

Based upon the results of this study, compliance with silvicultural BMPs can be improved by redirecting the nonpoint source pollution program to emphasize the following points.

- The recently published silvicultural BMP manual entitled, South Carolina's Best Management Practices for Forestry, should be promoted throughout South Carolina to reach as broad an audience as possible, including forest landowners, forest operators, and forestry professionals.
- BMP education and training programs should be developed for loggers and timber buyers. Limited state resources can be better utilized reaching loggers and timber buyers than less accessible forest landowners.
- BMP education and training programs should emphasize the identification and protection of sensitive sites. In particular, sites with perennial streams should be identified in the harvest planning process and these sites should be protected with applicable BMPs. Special emphasis should be placed in the Blue Ridge Mountain and Southern Piedmont regions where the density of drainage systems, land slope, and erodible soils combine to present challenges which are largely unique to these regions of the state.
- The silvicultural BMP monitoring program in South Carolina has documented an improvement in BMP compliance for harvesting operations from 84.5% in 1990 to 89.5% in 1993. Site preparation activities have the potential to impact water quality, but have not been monitored to date. A base-line monitoring program should be initiated for silvicultural site preparation activities on a statewide basis to determine the level of BMP compliance.

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